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Power Sector Reform in Nigeria: Challenges and Solutions

Kayode Oladipo[1], Agbetuyi A. Felix[1], Owolabi Bango[1], Obiakor Chukwuemeka[1], Fagbuaro Olawale[2]

[1]Department of Electrical and Information Engineering, Covenant University, Ota, Nigeria.
[2]Department of Electrical Engineering, Federal Polytechnic, Ilaro, Ogun State, Nigeria.
E-mail address: oluwafemi.kayode@accessbankplc.com

Abstract. Deregulation of electricity sector in Nigeria has brought to the fore, the need to explore power generation options for the improvement of power capacity, reliability, and availability. One of such options is the paradigm shift from centrally generated electricity to generation at the distribution level. Embedded generation is an emerging concept in the electricity sector, which represents good alternates for electricity supply instead of the traditional centralized power generation concept, though relatively new as a viable option in Nigeria. Embedded generation (EG) refer to any electric power production technology that is integrated within distribution systems, close to the point of use. EG saves cost due to on-site production which avoids transmission and distribution costs and hence, a saving of about 30% of the cost of delivered electricity. Also, on-site production of energy reduces loss of generated power due to transmission and distribution. It also improves the level of power quality and reliability aside from serving niche applications for remote sites. Distributed or embedded generation can provide standby generation (emergency power), peak shaving capability and cogeneration. It improves the efficiency of the power grid by having multiple micro-sources added to the system. Embedded generators are usually connected to the medium or low voltage grid. This paper therefore reviews power sector reform in Nigeria and its challenges. It presents the way forward for epileptic power supply by embracing embedded generation as a potential option to improving power supply in Nigeria.
Keywords: embedded generation; electricity; distribution; reliability; power reform

1. Introduction

Deregulation of electricity sector in Nigeria has brought to the fore, the need to explore power generation options for the improvement of power capacity, reliability, and availability. One of such options is the paradigm shift from centrally generated electricity to generation at the distribution level. Embedded generation is an emerging concept in the electricity sector, which represents good alternates for electricity supply instead of the traditional centralized power generation concept, though relatively new as a viable option, embedded generation is not a completely new concept globally. Embedded generation (EG) refer to any electric power production technology that is integrated within distribution systems, close to the point of use, and these generators are connected to the medium or low voltage grid.
In Nigeria, electricity is received from the transmission grid at 330/132kV and stepped down to lower voltages of 33kV, 11kV, 0.415kV and 240V, as it is distributed to end users. Domestic consumers receive their supply at 240Volts while industrial consumers (heavy users) can take their supply from either the 11kV or 33kV lines. Consequently, 330kVand 132kV are referred to as high voltage while the 33kV and 11kV and below range is referred to as medium/low voltage. Figure 1 and Figure 2 show the layout of a typical Nigeria transmission line.

Fig. 1. A typical primary transmission [1]

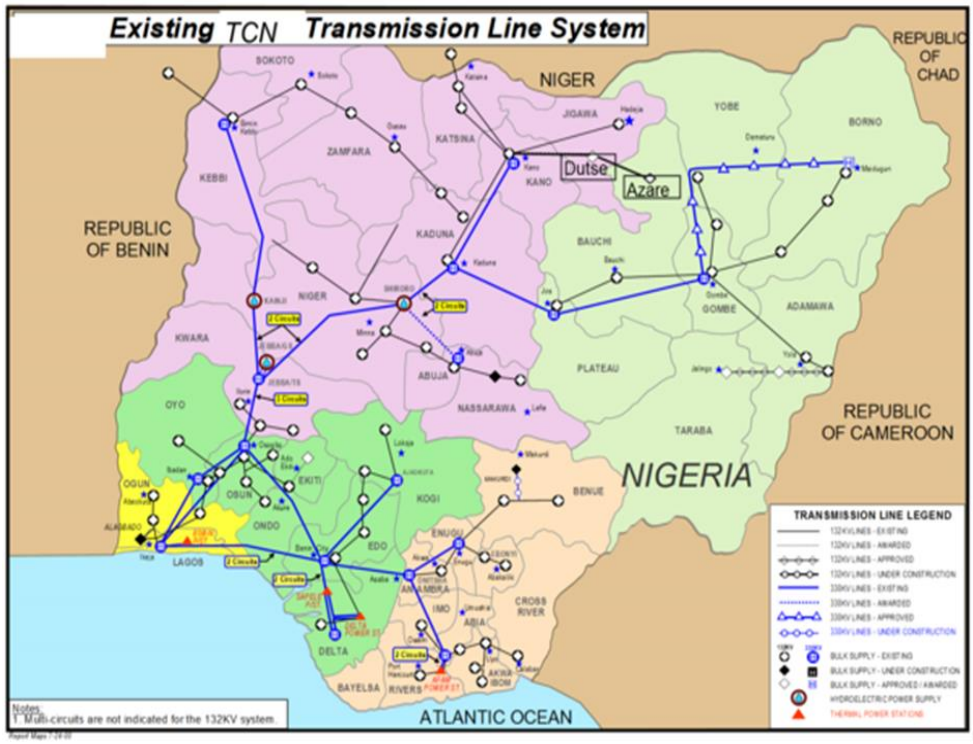

Fig. 2. Nigeria's transmission line system [2]

In recent times, numerous challenges facing central power generation is forcing a rethink of other viable options of getting electricity supply to the end-users. One such mechanism is to generate and power and supply proximal to the distribution network. This mode of power generation at the distribution level is called embedded or distributed power generation. The term distributed generation is often used to depict a small-scale electricity generation. However, there is currently no consensus on how embedded generation (EG) should be exactly defined as shown by the survey conducted by CIRED [3] and the assertions by [4]. The working group of CIGRE [5] devoted to distributed generation defines EG as all generation units with a maximum capacity of 50MW to 100MW, that are usually connected to the distribution network and that are neither centrally planned, nor dispatched. The International Energy Agency (IEA) on the other hand, considers EG as units producing power on a customer's site or within local distribution utilities, and supplying power directly to the local distribution network. In this case, no reference is made to the generation capacity level.

1.1. Power Generation in Nigeria

Power generation in Nigeria dates back to 1886 when two (2) generating sets were installed to serve the then Colony of Lagos. By an Act of Parliament in 1951, the Electricity Corporation of Nigeria (ECN) was established, and in 1962, the Niger Dams Authority (NDA) was also established for the development of hydroelectric power. A merger of the two (2) organizations in 1972 resulted in the formation of the National Electric Power Authority (NEPA) which was saddled with the responsibility of generating, transmitting and distributing electricity for the whole country. In 2005, as a result of the power sector reform process, NEPA was unbundled and renamed Power Holding Company of Nigeria (PHCN). The Electric Power Sector Reform (EPSR) Act was signed into law in March 2005, enabling private companies to participate in electricity generation, transmission, and distribution. The government unbundled PHCN into eleven electricity distribution companies (Discos), six generating companies (GenCos), and a transmission company (TCN). The Act also created the Nigerian Electricity Regulatory Commission (NERC) as an independent regulator for the sector.
At present, the Federal Government has fully divested its interest in the seven GenCos while 60% of its shares in the eleven (11) DisCos have been sold to the private operators. The Transmission Company still remains under government ownership. The generation companies created following the unbundling of PHCN are as shown in Table 1. The generation sub-sector presently includes 23 grid-connected generating plants in operation with a total installed capacity of 10,396 MW (available capacity of 6,056 MW) with thermal based generation having an installed capacity of 8,457.6 MW (available capacity of 4,996 MW) and hydropower having 1,938.4 MW of total installed capacity with an available capacity of 1,060 MW.

Table 1. Privatization status of seven power stations in Nigeria [5]

GenCo	**Installed Capacity (MW)**	**Type**	**Privatization Status**
Afam Power Plc	776MW	Gas	100% Sold
Sapele Power Plc	414MW	Gas	51% Sold
Egbin Power Plc	1,020MW	Gas	100% Sold
Ughelli Power Plc	900MW	Gas	100% Sold
Kainji Power Plant	760MW	Hydro	Long Term Concession
Jebba Power Plant	578MW	Hydro	Long Term Concession
Shiroro Power Plc	600MW	Hydro	Long Term Concession

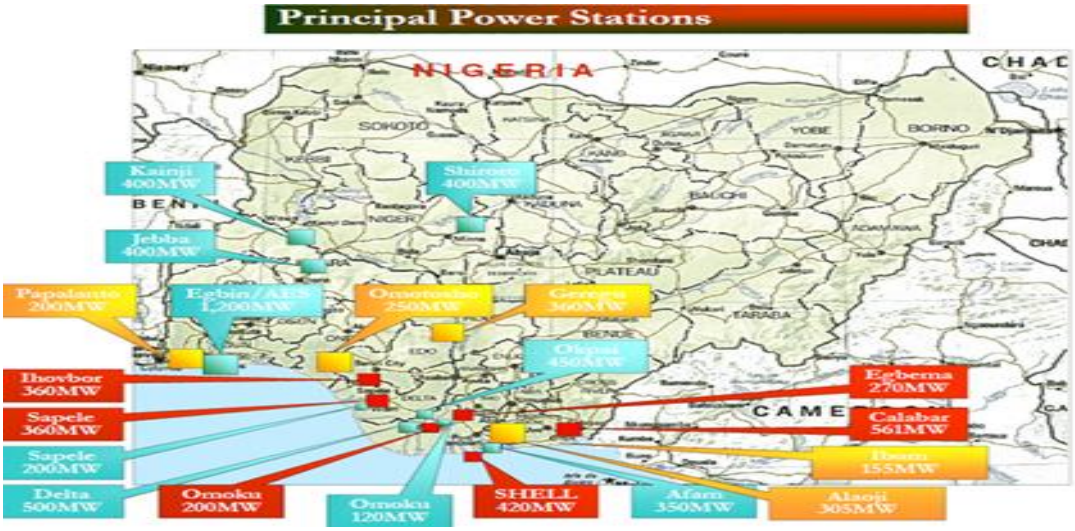

Fig. 3. Nigeria's principal power station system [6]

Figure 3 is the location of principal power stations in Nigeria and the installed capacity. However, in its effort to increase the level of power generation, the Federal Government in 2004, incorporated the Niger Delta Power Holding Company (NDPHC) as a public sector funded emergency intervention scheme. The company has a mandate to manage the National Integrated Power Projects (NIPP) which essentially involves the construction of identified critical infrastructure in the generation, transmission, distribution and natural gas supply sub-sectors of the electric power value chain [7]. In the generation sub-sector, NDPHC is expected to add ten (10) new gas fired power stations to the grid some of which have already been completed and commissioned, while others are at different stages of construction in different parts of the country. In total, the NIPP power stations will add about 4,774MW of power to the national grid network after completion [8].

The NIPP stations are listed below:

- Alaoji (1,074MW) in Abia state,
- Benin (Ihovbor) (451MW) in Edo state,
- Calabar (563MW) in Cross River state,
- Egbema (338 MW) in Imo state,
- Gbarain (225 MW) in Bayelsa State
- Geregu (434 MW) in Kogi State
- Olorunsogo (335MW)in Ogun state
- Omotosho (451 MW) in Ondo state,
- Omoku (225MW) in Rivers state.
- Sapele (450MW) (Ogorode)

Some of the NIPP power stations have already been privatized while plans are under way to sell the rest to interested investors in order to increase private sector participation in the sector thus strengthening the reform programme of the government.

In furtherance of the reform programme, the Nigerian Electricity Regulatory Commission (NERC) has in the past licensed several private Independent Power Producers (IPPs) some of which are at various stages of project development. The Commission has also enacted the Bulk Procurement Guidelines that will ensure the efficient and orderly procurement of large capacity generation in the future. This will enable the Commission to effectively predict the amount of power that can be added to the grid every year. The Commission has in addition developed a Regulation on embedded generation which allows for power generation plants (including renewable energy) to be directly connected to and evacuated through a distribution network. It provides a window for investors, communities, state and local governments to generate and sell or utilize power without going through the transmission grid. This also offers a means for DisCos to increase the amount of power available to sell while eliminating the transmission cost component of the tariff. By implementing reforms, Nigeria targets 40,000MW generating capacity by 2020

and will need to spend approximately $10bn per annum on the power sector for the next 10 years to achieve this [9] . In the post-privatized power sector, the Nigerian Bulk Electricity Trading PLC (NBET) purchases power generated by the GenCos and IPPs at agreed prices stated in Power Purchase Agreements (PPA) and resells to the DisCos who deliver the power to the end consumer

1.1.1. List of power stations in Nigeria

Twenty three (23) power plants are connected to the national grid. Below is a list of the power generation stations in Nigeria [14]:

1.1.1.1. Kanji power station reservoir.

Kanji power station is hydro-electric powered. It has an installed generating capacity of 760MW. It was completed by 1968 and is located at Niger state. This plant is presently generating 450MW, the plant cannot produce optimally due to old age and lack of proper Maintenance.

1.1.1.2. Jebba hydro power station reservoir

Jebba power station is hydro-electric powered. It has an installed generating capacity of 576.8MW and was commissioned in 1985. It is located in Niger state. This plant is presently generating 450MW, some of the turbine are bad due to lack of proper maintenance and well-trained personnel that can handle the machine.

1.1.1.3. Shiroro power station reservoir

Shiroro power station is hydro-electric powered. It has an installed generating capacity of 600 MW. It was completed in the year 1990 and is in full operation. This reservoir is situated at Niger state. This plant is presently generating 450MW, due to fund and proper maintenance.

1.1.1.4. Egbin thermal power station

Egbin power station operates on gas-fired steam turbine. It has an installed generating capacity of 1320 MW. The power station was completed between 1985 and 1986. It is located in Ikorodu of Lagos State. This plant is presently generating 1100MW, due to lack of proper Maintenance and well-trained personnel that could handle the machine.

1.1.1.5. Sapele power station

Sapele power station operates on gas-fired steam turbine and simple cycle gas turbine. It has an installed generating capacity of 1020 MW. Sapele power station was completed by 1981. It is situated in Ogorode – Sapele in Delta State. This plant is presently generating 90MW, due to faulty turbine and inappropriate funding of the power station.

1.1.1.6. Transcorp-Ughelli power station

Transcorp–Ughelli power station operates a simple cycle gas turbine. It has an installed generating capacity of 972 MW. Ughelli Phase 1 was built in 1966, Phase 2 in 1975, Phase 3 in 1978 and Phase 4 in 1990. The station is located in Ughelli of Delta state.This plant is presently generating 320MW.

1.1.1.7. Afam I-IV & V power station

Afam I-IV and V are thermal power plants operating on simple cycle gas turbine. Both plants were completed between 1982 and 2002. The power station has an installed capacity of 977MW. It is located in Afam in River state. This plant is presently generating 60MW, due to in adequate funding of the power station for sustainability.

1.1.1.8. Geregui power station

Geregu I Power station operates on open cycle gas turbine. It has an installed generating capacity of 414 MW. Geregu I Power station was completed by the year 2007. It is situated near Ajaokuta in Kogi state. This plant is presently generating 276MW due to inadequate funding.

1.1.1.9. Omotosho I power station

Omotosho I power station operates a simple cycle gas turbine with an installed generating capacity of 335 MW. It was completed by 2006. It is situated at Omotosho in Ondo state. This plant is presently generating 76MW, due to inadequate funding and shortage in gas supply.

1.1.1.10. Papalanto (olorunsogo) power station

Olorunsogo power station operates a simple cycle gas turbine. It has a total installed generating capacity of 335 MW. It was completed in the year 2007. This power station is located at Papalanto in Ogun state. This plant is presently generating 76MW, due to inadequate supply of gas and funding.

1.1.1.11. Kwale okpai power station (ipp)

Okpai power station operates on combined cycle gas turbine. It has an installed generating capacity of 480 MW. It was completed in 2005 as Independent Power Project. Okpai power station is owned by Agip Oil Company in Delta State.This plant is presently generating 361MW, due to inadequate funding.

1.1.1.12. Afam vi power station (IPP)

The combined cycle gas technology used in Afam VI Power plant contributes significantly to the reduction of greenhouse gas emissions. It has an installed generating capacity of 642MW. The plant was completed by 2010 and is situated in Rivers state. It is owned by the Shell Petroleum Development Company Joint Ventures. This plant is presently generating 450MW due to faulty turbine and non-availability of spare parts.

1.1.1.13. Ibom power station (ipp)

Ibom power station operates on simple cycle gas turbine. It has an installed generating capacity of 190MW. It was incorporated in 2001 and completed in 2009. Ibom power station has a proposed phase (II) with installed generating capacity of 500MW. This power plant is located at Ikot Abasi in Akwa Ibom state. This plant is presently generating 0MW, due to inadequate fund for completion.

1.1.1.14. AES Barge (IPP)

AES barge IPP operates on simple cycle gas turbine. It has an installed capacity of 270MW. The power plant was completed by 2001 and is located at Egbin in Lagos state. This plant is presently generating 224MW due to inadequate gas.

1.1.1.15. Omoku power station (IPP)

Omoku power station operates on simple cycle gas turbine. It has an installed generating capacity of 150 MW. It is currently under operation and was completed in 2005 and is situated in Rivers State. This plant is presently generating 60MW, due to defective turbine and inadequate gas supply.

1.1.1.16. Trans-Amadi power station (IPP)

Trans-Amadi power station operates a gas-fired system. It has an installed generating capacity of 136MW. It is situated in Rivers state. This plant is presently generating 60MW, due to defective turbine and inadequate gas supply.

1.1.1.17. Rivers IPP

Rivers IPP situated in Rivers state operates a gas-fired system. It has an installed generating capacity of 180MW. This plant is presently generating 0MW, due to lack of fund.

1.1.1.18. Aba power station (IPP)

Aba power station operates on simple cycle gas turbine. It has an installed generating capacity of 140MW. The power station was completed by 2012 and is situated at Aba in Abia state. This plant is presently generating 140MW, due to lack of fund and in adequate gas supply.

1.1.1.19. Geregu ii power station (NIPP)

Geregu II Power Station (NIPP) operates a simple cycle gas turbine. It has an installed generating capacity of 414MW. It was completed in the year 2012 and is situated in Kogi state. This plant is presently generating 276MW, due to inadequate funding and proper Maintenance of the turbine.

1.1.1.20. Sapele power plant (NIPP)

Sapele power plant is operated in simple cycle gas turbine. It has an installed generating capacity of 450MW. It was brought to completion by 2012. It is situated at Sapele in Delta state.

1.1.1.21. Alaoji power station (NIPP)

Alaoji power station (NIPP) operates on combined cycle gas turbine. It has an installed generating capacity of 1074 MW. The power station was completed by 2015. It is situated at Abia state. This plant is presently generating 0 MW.

1.1.1.22. Olorunsogo II power station (NIPP)

Olorunsogo II Power Station (NIPP) is situated at Olorunsogo in Ogun state. The power plant is operated on combined cycle gas turbine with an installed generating capacity of 675 MW. This plant is presently generating 0 MW.

1.1.1.23. Omotosho II power station (NIPP)

Omotosho power station operates on simple cycle gas turbine. It has installed generating capacity of 500MW. It was completed in the year 2012 and is currently under partial operation. It is situated in Omotosho Ondo state. The plant station is presently generating 76 MW.

1.1.1.24. Omoku II power station (NIPP)

Omoku II power station operates a simple cycle gas turbine. It has installed generating capacity of 225 MW. It is presently connected to the national grid. It is situated in Rivers state. The plant is presently generating 60 MW.

1.1.1.25. Ihovbor power station (NIPP)

Ihovbor power station operates on simple cycle gas turbine. It has a total installed generating capacity of 450MW. It was completed between 2012 and 2013. It is situated at Benin. This power station is presently generating 0 MW.

1.1.1.26. Egbema power station (NIPP)

Egbema power station operates on simple cycle gas turbine. It has an installed capacity of 338 MW. The power station was completed by 2013. It is situated at Imo state. This power station is not generating any megawatt to the grid.

1.1.1.27. Calabar power station (nipp)

Calabar power station operates on simple cycle gas turbine. It has an installed capacity of 561MW. It is located in Cross River state. This plant is presently generating 0 MW.

1.1.1.28. Gbarain power station (nipp)

Gbarain Power Plant has an installed capacity of 225MW. It is situated in Bayelsa State. Power Stations in Nigeria under Construction/Proposed. This plant is presently generating 0 MW.

1.1.1.29. Mambilla power station

Mambilla Power Station is a reservoir having an installed generating capacity of 3050MW. It is to be completed by the year 2018. The reservoir is located at Taraba state. It has not been completed due to lack of fund due to increase in spare parts.

1.1.1.30. Itobe power station

Itobe power plant located at Itobe Kogi State operates on circulating fluidized bed technology. It is coal fired power plant. It has an installed generating capacity of 1200 MW. It is yet to be completed by 2018.

1.1.1.31. Azura thermal power station (IPP)

Azura Thermal power station operates on simple gas turbine. It has an installed generating capacity of 450 MW. It is under development and is situated in Benin City.

1.1.1.32. Kano power station

Kano power station is hydro-powered. It has an installed capacity of 100 MW. The proposed completion date for the plant is the first quarter of 2017. It has not been completed due to present economy of the country.

1.1.1.33. Qua Iboe power plant

Quo Iboe power plant is a proposed power plant to be built in Akwa Ibom state. It is to have an installed generating capacity of 540MW. It will be one of the lowest cost thermal plants in Nigeria.

1.1.1.34. Zungeru power plant

Zungeru power plant is hydro-powered. It is to have an installed generating capacity of 700 MW and is to be completed by 2020. The power station is owned by the Ministry of Mines, Industry and Energy. It is located along the Kaduna River in Niger state.

1.1.1.35. Kaduna power plant

Kaduna power station is a dual fired power (gas/diesel) plant having an installed generating capacity of 215 MW. Its proposed completion is June 2017.

1.1.1.36. Gurara power plant

Gurara power plant is hydro powered. It has an installed generating capacity of 40 MW. It is located in Kaduna state.

1.1.1.37. Dadin kowa hydro power plant

Dadin Kowa power plant is hydro-powered with an installed capacity of 29 MW. Its proposed completion date is November 2019.

1.1.1.38. Okpai power plant phase 2

The Okpai Power Plant is to be completed by 2019. It has an installed generating capacity of 480MW.

1.1.2. Challenges Facing the Nigerian Power Sector

The poor performance of Nigeria's hitherto state – controlled power sector, resulting in unstable electricity supply and frequent blackouts, has been seen by ordinary Nigerians as evidence of the ineffectiveness of their governments. However, the situation has not improved much since the privatization of much power sector in recent years, even with continued government subsidies for some users.

Some other challenges are as detailed below [15]:

- Lack of proper funding faced by dwindling income due mainly to the collapse of global oil prices.
- The administration has the challenge of convincing frustrated electricity consumers that they must accept substantial increases in energy tariff if Nigeria is to achieve constant, stable and nationwide supply.
- This sector is facing myriad of structural problems that continue to hamper growth in the power sector. This include shortage of gas supply for thermal plants, high level of unpaid electricity bills and the country's outdated band poorly maintained transmission network, which the government still owns but put under private management.
- Also the existing transmission network cannot handle much more load than current peak electricity production
- Also many of the new power operators have struggled to make progress, especially as they have had to contend with aging facilities requiring substantial amounts of investments to upgrade and expand.

Fig. 4. Nigeria's power station [16]

In Nigeria, the operation of the power generation sector is driven by the privatized generation companies (GenCos), Independent Power Producers (IPP), and the generation stations under National Integrated Power Project (NIPP). Currently, the combined installed generating capacity is 12,500MW with about 74% contribution from the gas-powered plants [17]. The installed capacity of Hydro power station in Nigeria is 1,900 MW but the available capacity is 1,350 MW and this is due to aging and lack of proper maintenance of the turbine. The installed power station capacity in Nigeria is as shown in Table 2.

Table 2. Installed power station capacity in Nigeria, type and the available capacity [18]

Name	Site Location	Type	Installed Capacity (MW)	Available Capacity
AES Nigeria Barge Limited		Thermal	270	224
Afam Power PLC	Afam Rivers State	Thermal	987.2	60
Agbara Shoreline Power Limited	Agbara Ogun	Thermal	100	
Alaoji Generation Company Limited (NIPP)	Alaoji Abia State	Thermal	1074	
Anita Energy Limited	Agbara Lagos State	Thermal	90	
Azura Power West Africa Limited	Ihovbor Benin, Edo State	Thermal	450	
Benin Generation Company Limited	Ihonvbor Edo State	Thermal	450	
Calabar Generation Company Limited	Calabar Cross State	Thermal	561	
Century Power Generation Limited	Okija Anambra State	Thermal	495	
Enersys Nigeria Limited	Ado Ekiti State	Thermal	10	
Delta Electric Power Limited	Oghareki Etiope West LGA	Thermal	116	
DIL Power PLC	Obajana Kogi State	Thermal	135	
Egbema Generation Company Limited	Egbema Imo State	Thermal	338	
Egbin Power PLC	Egbin Lagos State	Thermal	1320	1100
Energy Company of Nigeria (NEGRIS)	Ikorodu, Lagos State	Thermal	140	
Enersys Nigeria Limited	Ado Ekiti Ekiti State	Thermal	10	
Ethiope Energy Limited	Ogorode, Sapele Delta State	Thermal	2800	300
Farm Electric Supply Limited	Ota-Ogun State	Thermal	150	
First Independent Power Company Limited	Omokun Rivers State	Thermal	150	60
First Independent Power Company Limited	Trans Amadi, Rivers State	Thermal	136	
First Independent Power Company Limited	Elewe, Rivers State	Thermal	95	
Fortune Electric Power Company Limited	Odukpani, Cross Rivers State	Thermal	500	
Gbarain Generation Company Limited	Gbarain, Bayelsa State	Thermal	225	
Geometric Power Limited	Aba, Abia State	Thermal	140	140
Geregu Power PLC (BPE)	Geregu Kogi State	Thermal	414	276
Hudson Power Ltd.	Warawa, Ogun State	Thermal	150	
Ibafo Power Station Ltd.	Ibafo, Ogun State	Thermal	200	
Ibom Power Ltd	Ikot Abasi Akwa Ibom State	Thermal	190	
ICS Power Ltd	Alaoji, Abia State	Thermal	624	
Isolo Power Generation Ltd.	Isolo, Lagos State	Thermal	20	
JBS Wind Power Ltd.	Maranban Pushit, Mangu, Plateau State	Wind	100	
Kainji Hydro Electric Plc (Kainji Station)	Kainji, Niger State	Hydro	760	450
Kainji Hydro Electric Plc (Kainji Station)	Jebba, Niger State	Hydro	540	450
Knox J&L Energy Solutions Ltd.	Ajaokuta, Kogi State	Thermal	1000	
Lotus & Bresson Nigeria Ltd.	Magboro Ogun State	Thermal	60	
MBH Ltd.	Ikorodu Lagos State	Thermal	300	
Minaj Holdings Ltd.	Agu-Amorji Nike Enugu East LGA, Enugu State	Thermal	115	
Nigeria Agip Oil Ltd.	Okpai Delta State	Thermal	480	361
Nigerian Electricity Supply Corporation (Nigeria) Ltd. (NESCO)	Bukuru, Plateau	Thermal	30	
Notore Power Ltd.	Onne, Rivers State	Thermal	50	
Ogorode Generation Company Ltd (NIPP)	Ogorode Delta State	Thermal	450	
Olorunsogo Generation Company Ltd (NIPP)	Olorunsogo, Ogun State	Thermal	750	
Olorunsogo Power Plc (BPE)	Olorunsogo, Ogun State	Thermal	335	76
Omoku Generation Company Ltd.	Omoku, Rivers State	Thermal	250	60
Omotosho Generation Company Ltd.	Omotosho II Ondo State	Thermal	500	76
Omotosho Power Plc (BPE)	Omotosho Ogun State	Thermal	335	35
Paras Energy & Natural Resources Development Ltd	Ogijo, Ogun State	Thermal	96	
Sapele Power Plc	Sapele, Delta State	Thermal	1020	90
Shell Petroleum Development Company Ltd.	Afam VI	Thermal	642	450
Shiroro Hydro Electric Plc	Shiroro, Niger State	Hydro	600	450
Supertek Electric Ltd.	Ajaokuta, Kogi State	Thermal	500	
Supertek Nigeria Ltd.	Akwete, Abia State	Thermal	1000	
Ughelli Power Plc.	Ughelli, Delta State	Thermal	942	320
Western Technologies & Energy Services Ltd.	Sagamu, Ogun State	Thermal	1000	
Zuma Energy Nigeria Ltd. (Gas Plant)	Ohaji Egbema, Owerri, Imo	Thermal	400	
Zuma Energy Ltd. (Coal Plant)	Itobe, Kogi State	Thermal	1200	
TOTAL			**25,255.2**	**4978**

1.2.2. The Overview of Nigeria Embedded Generation

Despite the huge investments by the government over the last years, it is an open secret that the nation is unable to boast of reasonable power supply to its citizens. The Nigerian population is above one hundred and eighty-three million and about 55% of the populations have no access to grid-connected electricity Access to electricity in the rural areas is about 35% and about 55% in the urban areas [19].

It has been estimated that developing economies would need about 1,000MW per million people to meet their electricity demand. Invariably, Nigeria would require more than 160,000MW to achieve the desired electricity generation capacity. Nigeria projects that by the year 2020, the country's generation capacity would be in excess of 40GW (40,000MW), and the energy mix will constitute 69% thermal generation; 17% hydro; 10% coal; and about 4% of renewable [20].

Faced with the myriad of problems, stakeholders in the nation's electricity industry have now adopted the embedded generation concept as a urgent strategy to immediately procure electricity for customers, while waiting for national grid power improve significantly. Presently, the installed power generation capacity in Nigeria is 12,522MW; out of which 10,592MW is gas fired; and 1,930MW is from hydro. It is worth noting that out of the total installed capacity, the maximum peak generation by power plants as at February 13, 2018 was 4,083.34MW [21]. The integration of distributed sources into existing networks is becoming a viable option in modern power system networks considering its numerous advantages such as: cost saving due to on-site production which avoids transmission and distribution costs and hence, a saving of about 30% of the cost of delivered electricity. Also, on-site production of energy reduces loss of generated power due to transmission and distribution [22].

Further, embedded generation improves the level of power quality and reliability aside from serving niche applications such as remote sites. Distributed or embedded generation can also provide standby generation (emergency power), peak shaving capability and cogeneration. It also improves the efficiency of the power grid by having multiple micro-sources added to the system [23]. The Nigeria Electricity Regulatory commission (NERC)'s embedded generation regulation allows an independent power producer to integrate power with the network of the local distribution company without going through the trouble of connecting to the transmission network. This allows distribution companies to procure small power and dedicate it to ring – fenced customers 24/7 electricity supply [24].

Power investment expert said the Federal, states and private sector power plant investors have immense benefits to gain from investing in embedded generation. He also noted that embedded generation has the prospects to achieve national aspirations within a shorter time; reduce technical losses because of proximity to the network, and deepen the electricity market – capacity, standards, contracts and more bankable deals [25]. With embedded generation, Discos would have access to more power supply more cash flows while more customers would be willing to pay. According to him, "It presents opportunity for discos to improve distribution network – either by themselves or by EGs – and performance. The recent Regulations on Embedded Generation and independent Electricity Distribution Networks issued by the Nigeria Electricity Regulation Commission (NERC) (Pursuant to its power to make regulations under the Electric power sector reform Act, 2005) confirm the commitment of the Federal Government to tackling the inefficiencies in Nigeria power sector [26].

The Regulations were issued as part of the effort to improve generation and realize the Federal Government's target of achieving a generation capacity of 40,000MW by the year 2020. Another compelling reason was the need to provide electricity for about 55% of Nigeria population without access to electricity as many communities have no access to the national grid. Furthermore, many of the area connected to the grid experience very frequent power outages [27]. For power developers, IPPs can sell excess power to discos. It guarantees cost reflective tariff. There is immense potential market for power supply to housing estates, industrial estates/clusters, state governments and telecom installations. There is also option to also supply power to eligible customers. No distribution lines are ordinarily required when connected to a disco. No transmission costs would be incurred and no distribution license required according to [28].

The chairman of Nigeria Electricity Regulatory Commission (NERC) recently issued license for embedded power generation to Bauchi state government. Also, Eko Electricity Company of Nigeria has concluded plans to generate over 1000MW of electricity through embedded power generation model 2019 [29]. Embedded, dispersed or distributed generation (DG) are synonyms for an upcoming probable paradigm shift in electric power generation, including smaller-scale generation, combined heat and power (CHP), energy storage, load management and energy efficiency [30]. Recently, the Lagos State government is working towards passing into law Lagos State Electric Power Sector Reform Bill.

2.2.3. Benefits of Embedded Generation

To the end-user, Embedded Generation offers numerous benefits when properly sited, sized, installed, and operated. Among these benefits are:

- It can significantly improve reliability of energy supply, providing a very critical solution to businesses and industries with continuous processes and in situations where health and safety is impacted.
- The wide variety of EG technologies offers the opportunity of selecting the right energy solution at the right location. EG technologies can provide a stand-alone power option for areas where transmission and distribution infrastructure does not exist or is too expensive to build.
- It may offer efficiency gains for on-site applications by avoiding line losses, and using both electricity and the heat produced in power generation for processes or heating and air conditioning.
- Its flexibility of operation because of small modular units enables savings on electricity rates by self-generating during high-cost peak power periods and adopting relatively low cost interruptible power rates;
- Benefits for environmental quality may come from embedded generation's role in promoting renewable energy sources, less-polluting forms of fossil energy, and high efficiency technologies. EG allows power to be delivered in environmentally sensitive and pristine areas by having characteristically high efficiency and near-zero pollutant emissions;
- EG limits capital exposure and risk because of the size, siting flexibility, and rapid installation time afforded by the small, modularly constructed, environmentally friendly, and fuel flexible systems;
- Unnecessary capital expenditure can be prevented by closely matching capacity increases to growth in demand;
- EG avoids major investments in transmission and distribution system upgrades by siting new generation near the customer;
- It offers a relatively low-cost entry point into a new and competitive market;
- Opens markets in remote areas without transmission and distribution systems, and areas without power because of environmental concerns.
- EG responds to increasing energy demands and pollutant emission concerns while providing low-cost, reliable energy essential to maintaining competitiveness in the world market; and
- Establishes new industry worth billions of dollars in sales and hundreds of thousands of jobs and enhances productivity through improved reliability and quality of power delivered, valued at billions of dollars per year.

3. Suggested Solutions to erratic Power Supply in Nigeria

There is a need to create an investor friendly environment for embedded generation solutions, which will allow for government support, tax incentives and reliefs to encourage investments in the power sector. Examples of efforts in this regard include the National Renewable Energy and Energy Efficiency Policy for the Electricity Sector newly approved by the Federal Government; and the Renewable Energy Master Plan developed for Nigeria [29].

It is important for Nigeria to intensify efforts in seeking funding support from the World Bank, Development Finance Institutions and NGOs for the purpose of electrifying Nigeria. The Bangladesh off-grid success story was possible through the support of these institutions.

Nigeria should invest in renewable energy resources. Nigeria is reported to have potentials for harvesting strong wind energy throughout the year from coastal areas like Lagos State through Ondo, Delta, Rivers, Bayelsa to Akwa-Ibom States [31]. Though the initial cost of installing a turbine generator is huge but thereafter the benefits are huge. This will go a long way to improve power supply in Nigeria.

The embedded generation concept should be decentralized among the federal, state and local governments. There should be an increase in energy tariff if Nigeria is to achieve constant, stable and nationwide supply. The customers are willing to pay as long as the power is stable and reliable.

4. Conclusion

Proper funding of the power generation station in Nigeria would improve power generation. The gas lines conveying gas to gas station should be remotely secured against vandalization. The huge outstanding

electricity bills owned by individuals and government agencies must be paid. Also, the existing transmission network must be adequately maintained and revamped to accommodate much more load than current peak electricity production. Investment in renewable energy resources will help in power stability in Nigeria. Finally, integration of embedded or distributed generation into the existing injection substation will guarantee stable power supply in Nigeria. This has worked in other countries of the world and so it can also work in Nigeria.

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